ARMORED MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

Partial Report On

THE USE OF RED LIGHT FOR MAINTAINING DARK ADAPTATION IN TANKS

Project Nos. 7-2, 7-3

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ARMORED FORCE MEDICAL RESEARCH LABORATORY
Fort Knox, Kentucky

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File No. 400.112-6 AFMRL

December 5, 1942

PARTIAL REPORT ON THE USE OF RED LIGHT FOR MAINTAINING DARK ADAPTATION IN TANKS

1. PROJECT: 7-2, Determination of the Type of Illumination Least Disturbing to Dark Adaptation in Tanks. 7-3, Investigation of Methods of Improving Night Vision in Tank Crews by the Use of Eye Appliances.

a. Authority - Letter Commanding General, Headquarters, Armored Force, Fort Knox, Kentucky, GNOHD 400.112/6, dated September 24, 1942.

b. Purpose - To investigate the effect of filtered red light on the dark adaptation of tank crews and to determine the adequacy of the illumination provided.

2. DISCUSSION:

a. Analysis of the position of tanks in respect to night operations is given in Appendix I with outline of the possibilities for improvement.

b. The full utilization of remedies depends upon the maintenance of a high degree of dark adaptation by the personnel. The present illumination in tanks is grossly disturbing to dark adaptation and is needlessly bright. Comparison of the minimum amounts of illumination required for various tasks with that actually provided is given in Appendix II.

c. Tank movements at night will require periodic inspection of maps and since this operation requires the most illumination it was used as the standard task in this study. Details of the test procedure are given in Appendix III; the results in Appendix IV.

3. CONCLUSIONS:

a. The present interior illumination in M-4 tanks causes loss of dark adaptation and lowers the efficiency of night vision.

b. Filtered red light of the characteristics specified is superior to the present lighting in preserving dark adaptation.

c. The wearing of red goggles will preserve dark adaptation equally well.

d. Filters are preferred since their use eliminates many of the disadvantages of goggles - steaming, leakage, etc.

e. Even with the filters attached, the lights in the M4A2 tank provide adequate illumination for work. In the M4A3, however, the arrangement and design of the lights is such as to require modification if sufficient illumination is to be provided with the red filters installed.

f. Further gains in visual efficiency inside tanks can be achieved by making the changes suggested in Appendix V.

4. RECOMMENDATIONS:

a. That ten (10) M-4 medium tanks be equipped with red filters and these tanks be used in night problems by a field unit to determine the adequacy of lighting under a variety of conditions.

b. That other changes (Appendix V) be made in these tanks to secure the maximum improvement possible.

c. That night vision testing of the tank crews to be used for night operations be carried out.

d. That instruction in the proper use of the eyes at night be given these men prior to the night operations.

Reported by:

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9 Incls:
(Appendices I-V)
(Curves I-IV)

APPENDIX I

ANALYSIS OF THE POSITION OF TANKS IN RESPECT TO NIGHT OPERATIONS

The tactical advantages of being able to carry out night operations with tanks are obvious and considerable advantage is held by the force that can see and perform best under conditions of poor illumination. Sufficient improvement in night vision from tanks may not only permit one to see when the enemy cannot, but will also enable one to see much better than he can during the twilight period.

Tank operations at night are now restricted by several limitations:

a. Driving is difficult without headlights even when the driver is fully dark-adapted.

b. The interior lighting is so bright as to dazzle the crew and materially interfere with dark adaptation. The intensity, moreover, is so high as to reveal the presence of the tank for distances of from 1/8 to 1/4 mile.

c. The light transmission of the periscopes and the periscopic sight is too low to permit their use at night.

d. Men with subnormal night vision may by chance be used in tank crews since there is now no selection for night visual abilities.

e. Training in night operations and in the use of the eyes at night is not being fully utilized.

Certain of these restrictions can be eliminated; others greatly reduced. The following measures are suggested and will be made the subject of investigation.

a. Correction of interior lighting and maintenance of maximum dark adaptation by utilization of all advantages. (Subject of present report.)

b. Development of a satisfactory night sight.

c. Selection of men with the best night vision for night operations.

d. Development of methods for the training of selected men in night operations and in the proper use of the eyes at night.

APPENDIX II

LIGHTING REQUIREMENTS FOR VARIOUS POSITIONS AND TASKS IN M-4 TANKS

The following estimates of the minimum amounts of illumination required have been arrived at from study of work in tanks, from reports of other investigators and from findings in the Laboratory. They represent the lighting necessary for most subjects to carry out the tasks successfully; if greater amounts can be provided without seriously interfering with dark adaptation, work will be expedited.

	Illumination required (footcandles)			
			Now provided	
Task	Day	Night	White	Filtered
Map reading	3.0 +	0.3	.3 - 1.8	.018 - .08
Radio operation	0.6 +	0.025	.4	.01
Passing ammunition and loading (75 mm)	0.3		.002	x
Machine Gun loading and clearing		0.03	.026	.002 (Asst. Driver)
			.045 - .5	.004 (Turret)

The values shown for light now provided are for the M-4 A-3 tank which has interior lights different from those in the M-4 A-2 tank on which the other data of this report was determined. The loss of light by the use of the filter in the M-4 A-3 is greater than that in the M-4 A-2 due probably to the plastic diffusion lens used in the former. The problem of adapting this light with a red filter is being worked on and an experimental installation will be ready in the near future.

APPENDIX III

TEST PROCEDURE

The first part of the program was to determine the degree of disturbance of dark adaptation from the reading of maps illuminated by the existing lights in the driver compartment and turret of M-4 tanks. Tests were carried out in the field on dark nights with the subjects fully dark adapted. After various timed exposures to map reading, the time required to identify a variety of targets was taken as the measure of loss of dark adaptation.

In the second set of experiments comparison of the degree of loss of dark adaptation was made between:

a. Map reading under white light, with and without goggles; and,

b. Between map reading under white light and filtered red light.

Tests were carried out in the Salt River range area, well away from the road, in a light-protected location. The targets were set up in front of the tanks and tests begun when adaptation was complete. Periodic measurements of brightness were taken of the sky, targets, and backgrounds. The subject took his position in the drivers seat or commanders position, the operator, standing-by, (either in the assistant drivers position or in the turret) manipulated the light and supervised the movements of the subject. Timing was controlled by the recorder outside the tank. The first tests were made using a dimly illuminated target with changeable bars, the subject being required to designate the position of the bar. For the second test, a non-illuminated sign $1\frac{1}{2}'$ x $1\frac{1}{2}'$ was used. In the third and fourth tests the subject was required to identify the orientation of a black Landot ring 8" in diameter on a $2\frac{1}{2}'$ white target. Tests with red and white lights were carried out simultaneously, the subjects alternating positions between the tanks equipped with red and white lights.

At the conclusion of the light-exposure period within the tank, the subject upon signal, raised his head outside and attempted to determine the orientation of the test object. The time interval between the end of the dazzle period and the instant of recognition was recorded as recovery time.

In these tests the filter material was inserted as a strip within the light guard or as a disk over the warning lights. For permanent installation, light covers will have to be designed to position the filter in appropriate places to secure proper distribution. The transmission curve for the material used (Polaroid Co., non-polarizing #8AP) is given in curve 4 Appendix. The present material is the only now available with suitable transmission characteristics. It has the disadvantage of being inflammable. However, as development proceeds it will undoubtedly be possible to obtain filters of non-inflammable material.

APPENDIX IV

RESULTS

Curve I shows the results obtained for two subjects using the illuminated target set 30' in front of the tank. It can be seen that with no light-exposure the target was recognized instantaneously. After one minute of dazzle about 15 seconds were required for recovery and after two minutes of map reading from 30 to 60 seconds were necessary, the two subjects (curves A & B) having different rates of recovery.

Curve II shows the results obtained with non-illuminated sign of low visibility. One subject wore red goggles while reading the map. His recognition time throughout for all objects was 2 seconds as shown by dashed line. In the case of the subject without goggles the recognition time for the small target is given for various periods of map reading in Curve A.

Curve III gives the averages for a number of subjects in the tank equipped with red filters over the lights and in the tank equipped with white light. It can be noted that after 2 minutes of map reading—the test object was identified in 6 seconds by the crew exposed to red light while 30 seconds were required for an equal degree of recovery by the crew of the tank with unaltered lighting.

APPENDIX V

IMPROVEMENT AND MODIFICATION

GENERAL CONSIDERATIONS:

This report should be considered as a part of the more general problem of bettering night vision which overlaps somewhat the problem of dawn and dusk vision. Means of obtaining better vision are often subtle and may be overlooked or discounted because the apparent advantages taken individually may be small. Good night vision or good day vision is the result of many factors and best vision is that which takes full advantage of all controllable factors.

What can be seen is the combined result of the function of the eye and the illumination of the objects seen. The selection, education and training of men will aid in putting the best eyes where they are most needed and will make possible the best use of the eyes. The illumination of outside objects is not controllable—the inside illumination of the tank is, and must be sufficiently bright on the one hand to permit performance of all of the necessary duties within the tank but dim enough on the other hand so as not to interfere with dark adaptation. White light bright enough for map reading and other necessary duties will interfere with dark adaptation and if dimmed down to where it will not interfere with dark adaptation is not sufficiently bright for the performance of these duties. The results in this report confirm findings elsewhere that red filtered light effects dark adaptation less than white—hence it should be possible by reducing inside red brightness to the minimum necessary for map reading and performance of other duties to give a substantial improvement in maintenance of dark adaptation over that possible with white light. At practical light levels of either white light or red light there is not sufficient brightness to read fine detail. Ability to read maps at low light levels is dependent upon the reflectance factor, the degree of contrast of markings and the size of markings. The finer the detail and line, the greater the illumination required for reading. Maps issued for night operations should be drawn to include only the essentials; printing should be black on white and all markings boldly drawn.

Control knobs should be of maximum contrast—painted white on black.

Lettering on azimuth ring. In general, illumination required for visibility varies as the square of the size of the lettering. Consequently, a relatively small increase in letter size will permit a relatively large reduction in illumination. Where an azimuth circle is used a black ring should be painted around the turret with azimuth markings in white.

Oil pressure warning lights should be fitted with the red filter material since they will cause some dazzle as now illuminated. Recoil box warning light

IMPROVEMENT AND MODIFICATION

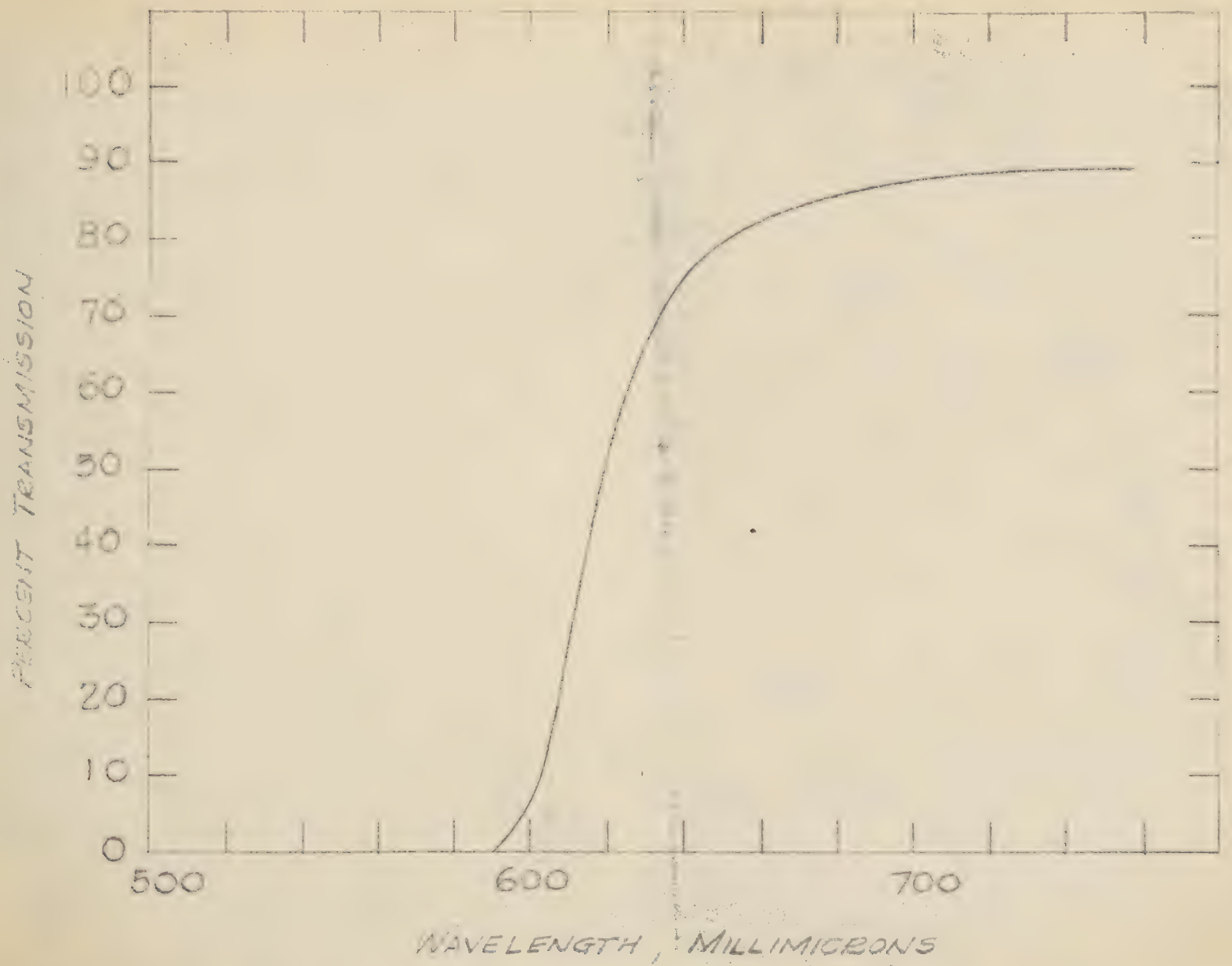
should be fitted with red filter material for the same reason.

Filtered light has advantage in other situations; it can be used effectively for inside lighting in other vehicles, particularly those used in reconnaissance or patrol. It should be used in any situation where it is desirable to preserve dark adaptation but where illumination is necessary for work. Flashlights to be used by sentries, observers, reconnaissance leaders, scouts and guides can be easily fitted with the filter material by simple substitution for the existing lens.

a. Light fixtures should be placed to give maximum illumination where needed most. The proper location of lights and positioning of shields, if needed, will be determined in the course of the field experiment.

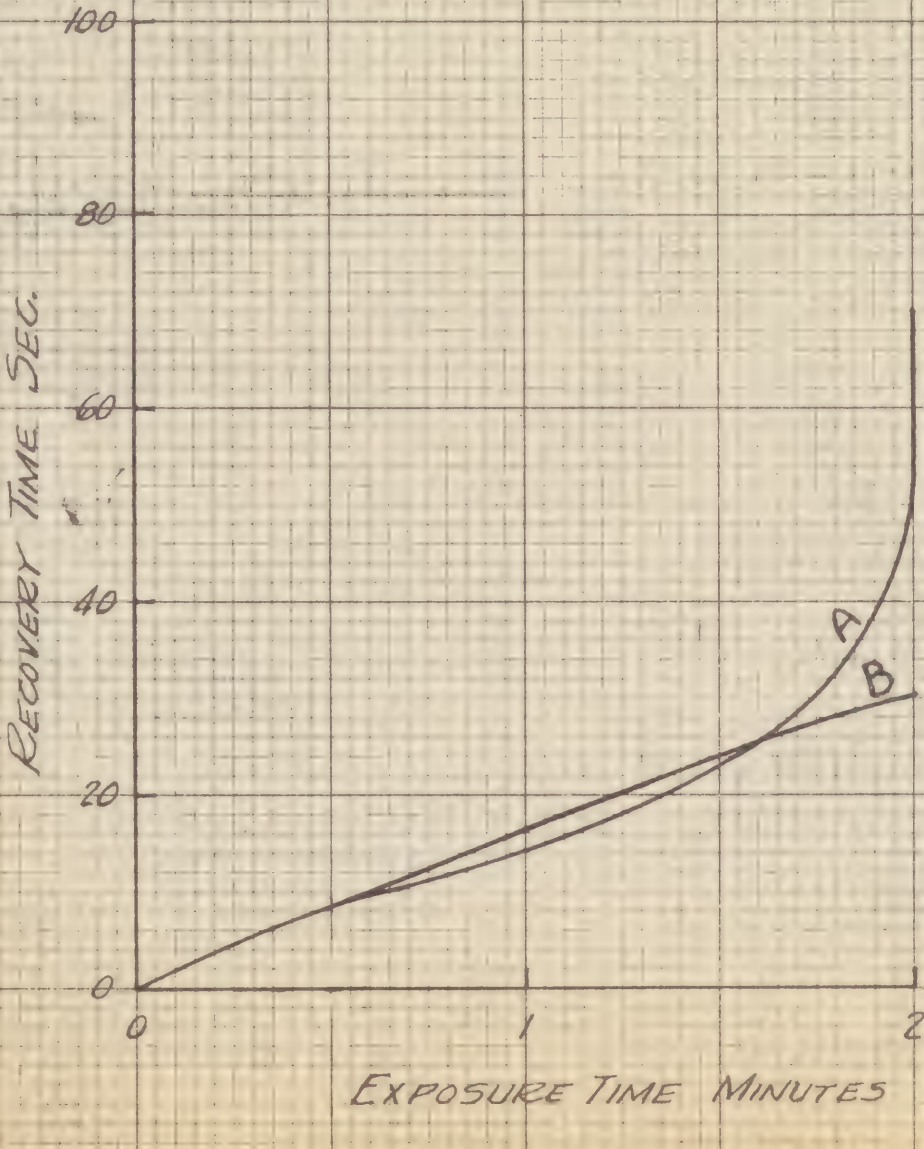
b. Flashlights for night use in the tanks should be provided with the filter material.

TRANSMISSION CURVES OF RED FILTER MATERIAL

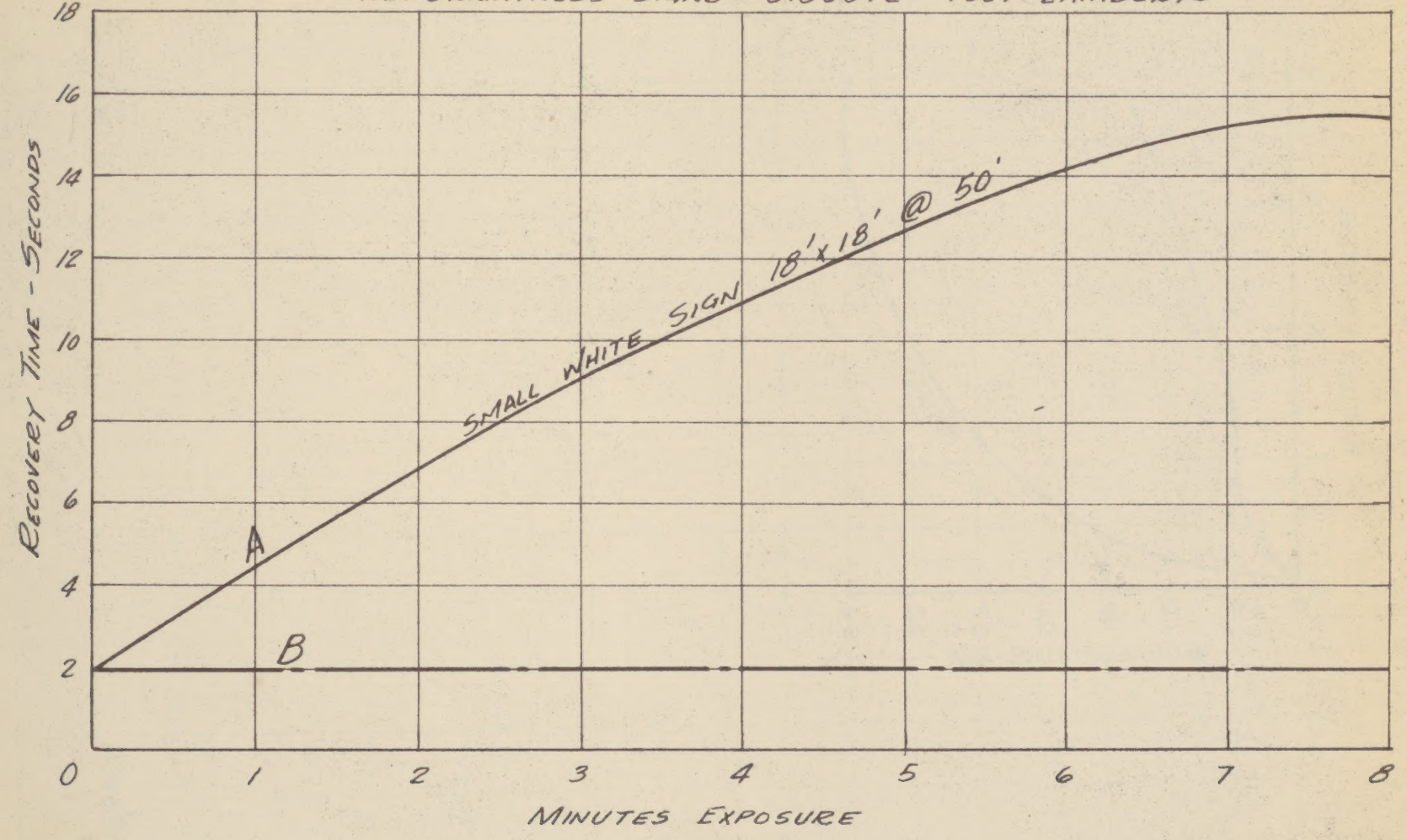


CURVE I

TARGET BRIGHTNESS .000035 FOOT LAMBERTS



AVE. BRIGHTNESS DISC - 0.000601 FOOT LAMBERTS
AVE. BRIGHTNESS SIGNS - 0.00012 FOOT LAMBERTS



CURVE II

AVERAGE

CURVE III